The SNO+ Experiment

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Introduction

SNOLAB

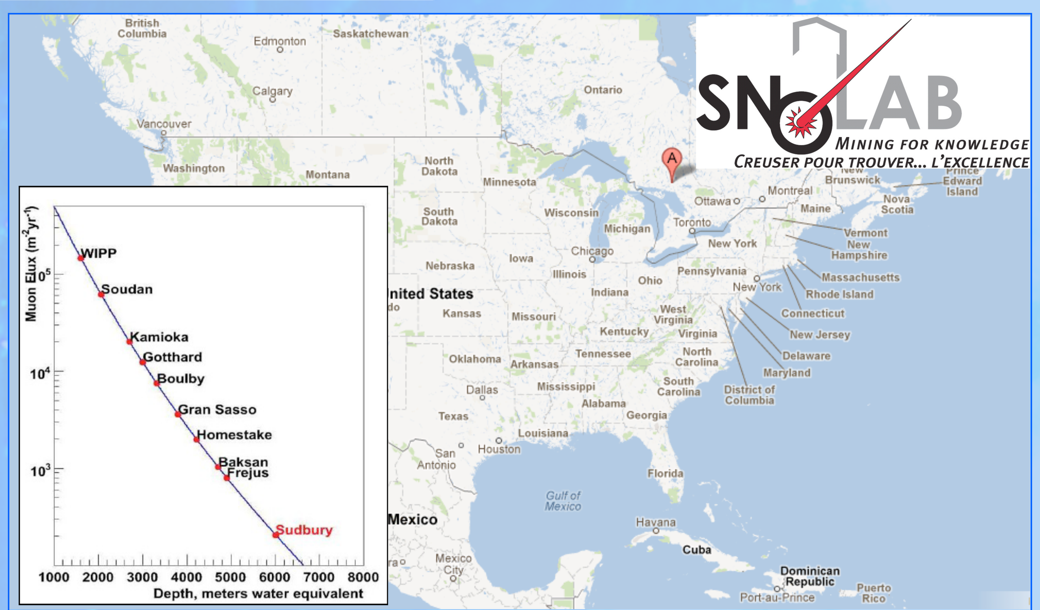


Fig. 1: SNOLAB location and depth.

SNOLAB is located in the Creighton mine near Sudbury, Canada. It contains several neutrino and dark matter search experiments. At its depth of ~2200m the flat overburden equals about 6000mwe. This reduces the expected muon-rate in SNO+ to roughly 70 muons per day.

SNO+

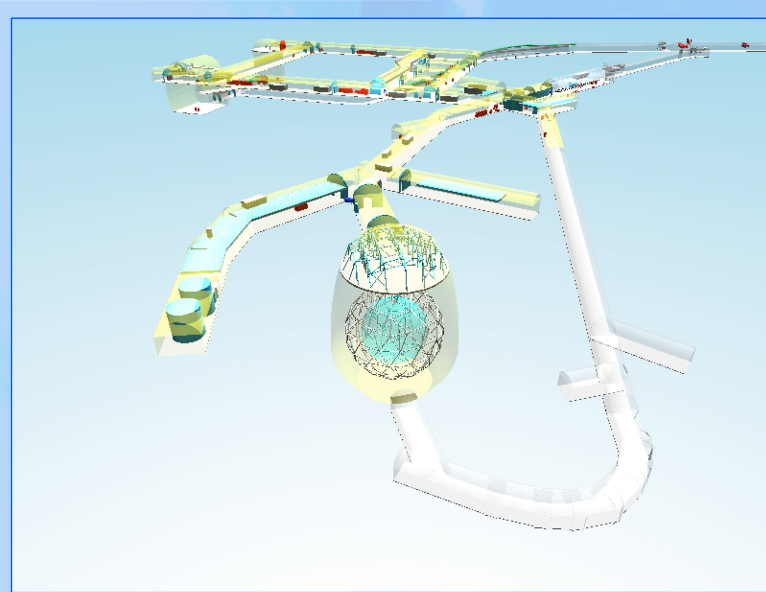


Fig. 2: The location of the SNO+ detector inside SNOLAB.

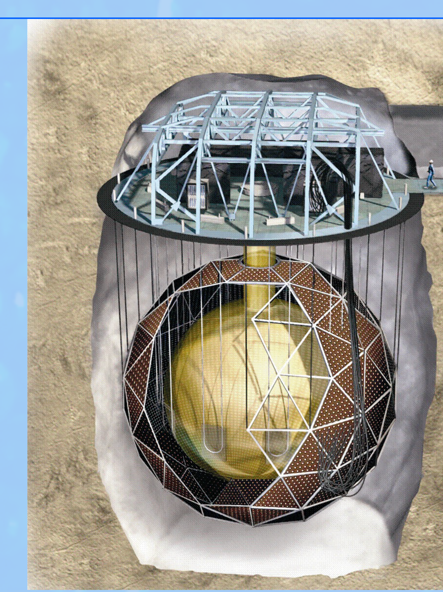


Fig. 3: The SNO+ detector.

The SNO+ experiment uses the existing Sudbury Neutrino Observatory (SNO) and liquid scintillator (LAB+PPO) as the target material. This way, a low background level and a low energy threshold can be achieved. Among the SNO+ scientific goals are the study of solar and supernova neutrinos, anti-neutrinos from reactors and the Earth's natural radioactivity.

0νββ with SNO+

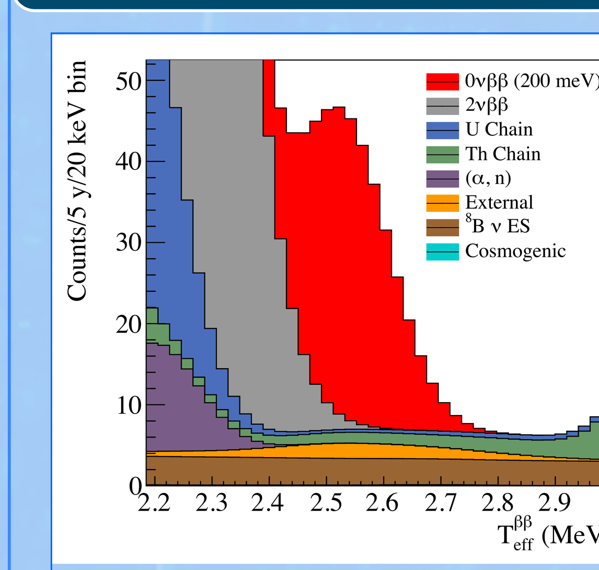


Fig. 4: The SNO+ predicted energy spectrum for 0.5% natural Te loading, 390NHit/MeV, 5 life-years within a 20% fiducial volume cut (3.5 m).

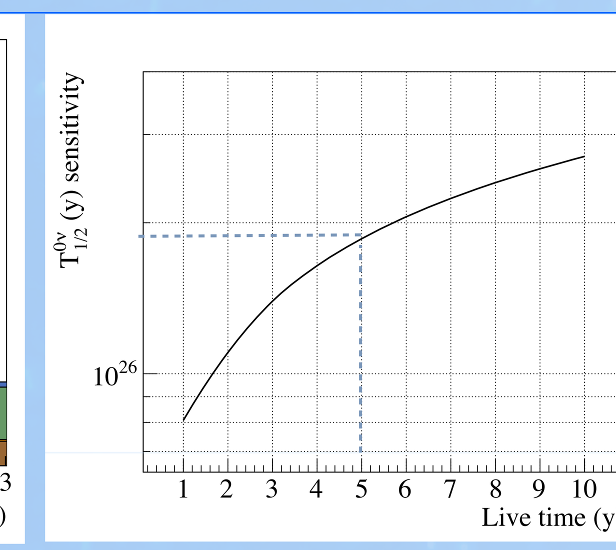


Fig. 5: ^{130}Te half-life sensitivity vs. live-time for 90% CL.

The main physics goal of SNO+ is to search for neutrinoless double beta decay. In an initial phase, 0.5% loading of natural Tellurium will be added to the scintillator which results in about 1300 kg of ^{130}Te. SNO+ will then reach a competitive Majorana mass sensitivity of 38-92meV in 5 years.

Cherenkov Calibration Source

The overall light collection efficiency is a critical factor in modeling the energy scale and resolution of SNO+. Extracting this can be achieved by deploying a source that produces a well understood and easily simulated optical signal. The SNO+ Cherenkov Source is designed to produce this signal through tagged Cherenkov events.

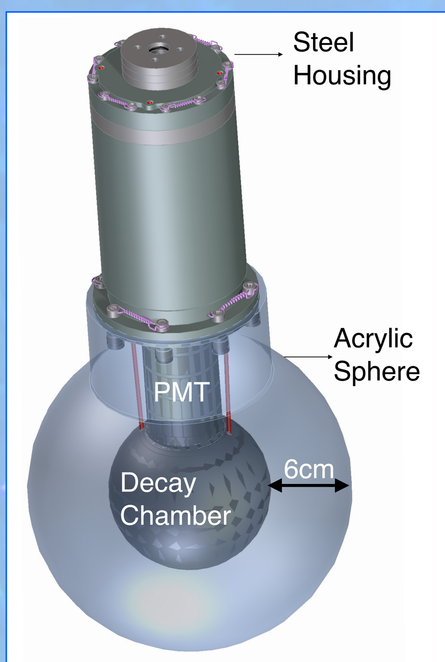


Fig. 6: The Cherenkov source.

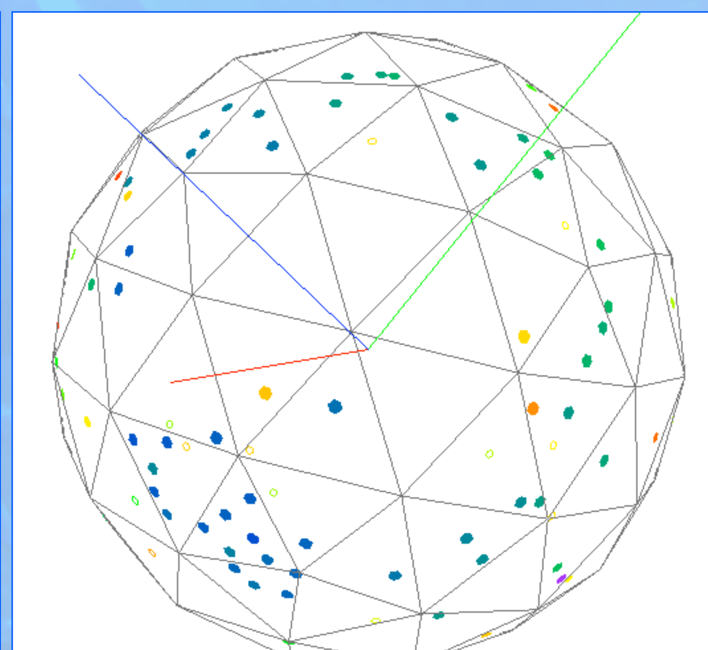


Fig. 7: An 8MeV electron simulated in the center of the Cherenkov source, positioned at 2m along the x-axis.

Principle: ^{8}Li ($t_{1/2}$ = 838ms) is carried at high speed by He gas through a tube into the decay chamber.

$^{8}Li \rightarrow {}^{8}Be + \beta^{-} + \nu$; $^{8}Be \rightarrow 2\alpha$; β^{-} endpoint at 13MeV

The β^{-} produces Cherenkov light in the acrylic wall, and is stopped. α's produce scintillation light in the He gas, which is used to tag the event. Use of UVA acrylic minimizes impact of scintillator on propagated photons.

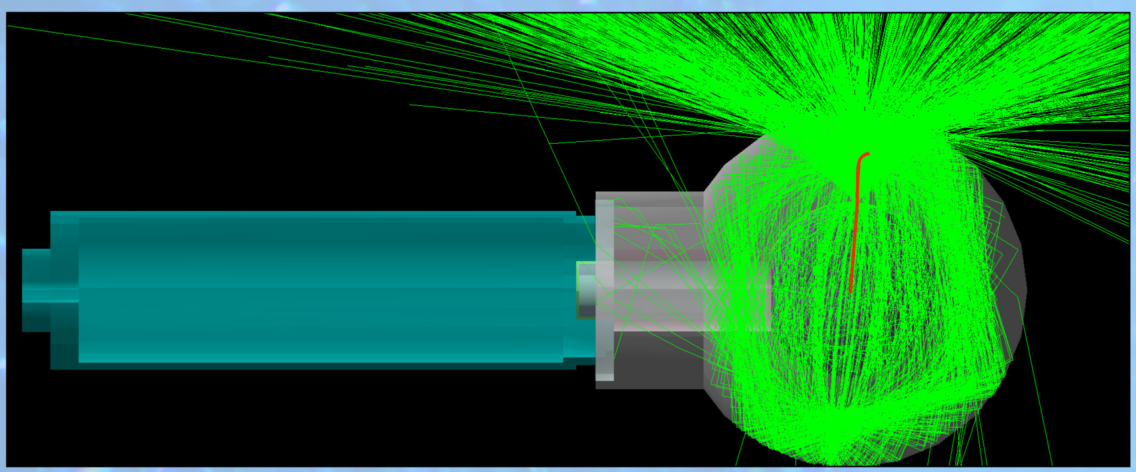
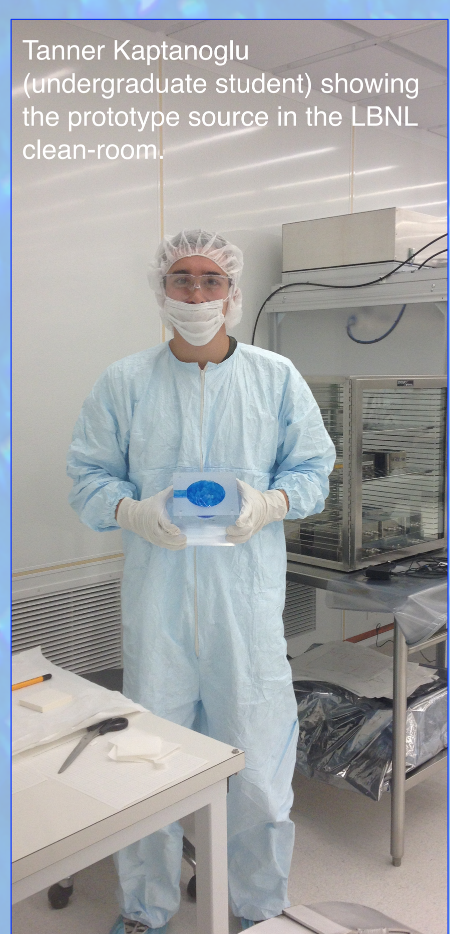
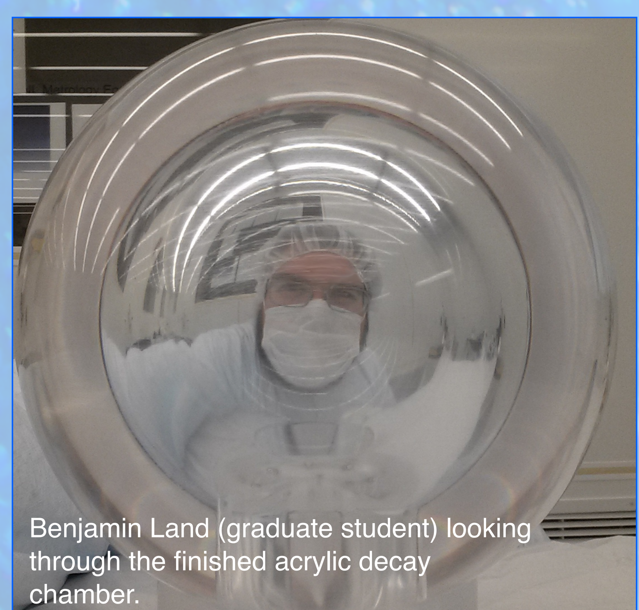


Fig. 8: A simulated Cherenkov source using an 8MeV electron (red track). In green are the Cherenkov photons.



Tanner Kaptanoglu (undergraduate student) showing the prototype source in the LBNL clean-room.

The Cherenkov source design has been finalized and is currently under review by the SNO+ source committee. There are no major outstanding issues.

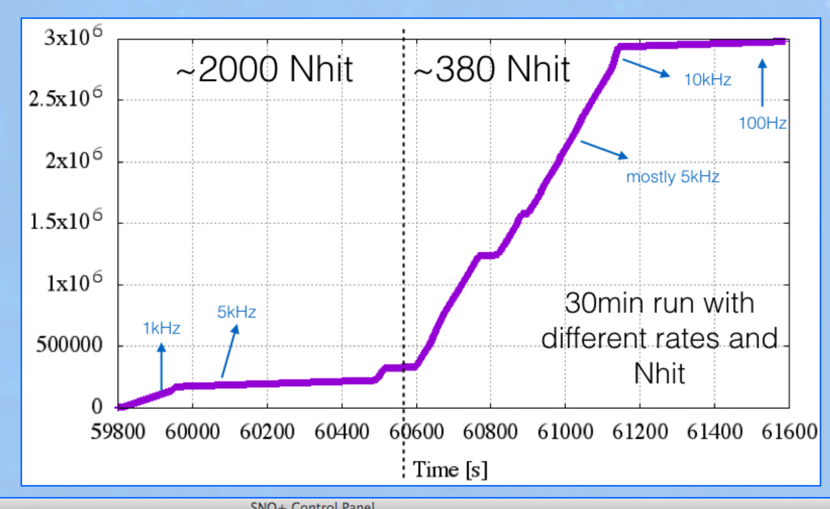


Benjamin Land (graduate student) looking through the finished acrylic decay chamber.

New DAQ System

A new DAQ system has been developed for SNO+. The use of a modular approach decouples data flow from detector control (ORCA) and monitoring tools. This provides more stability and increased control. The DAQ has been stress-tested at high rates during air-fill running.

Fig. 9: (on the right) Event number versus time for a stress-test run.



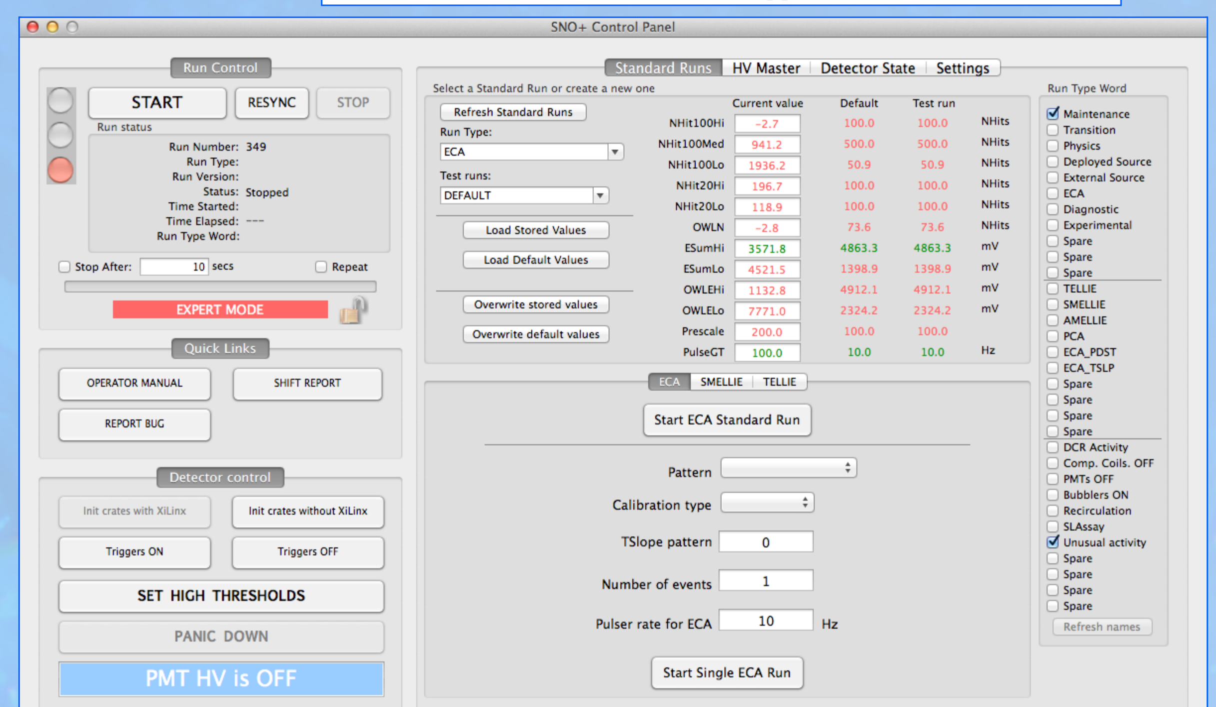


Fig.10: ORCA screenshot showing the user-GUI for non-expert operators. Detector state for each run is recorded in a database, allowing clear reproducibility of runs.

Electronic Upgrades

SNO+ has implemented substantial upgrades to the electronics of SNO in order to compensate for the higher data rates and light output expected by a scintillator experiment. All the new components have been installed and commissioned during the initial air-fill and partial water-fill runs.

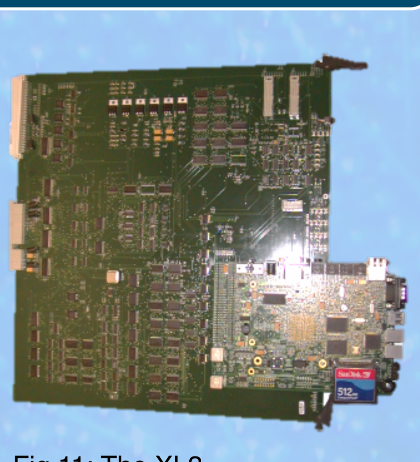


Fig.11: The XL3.

- **XL3:** Readout cards can handle the higher data rates expected.

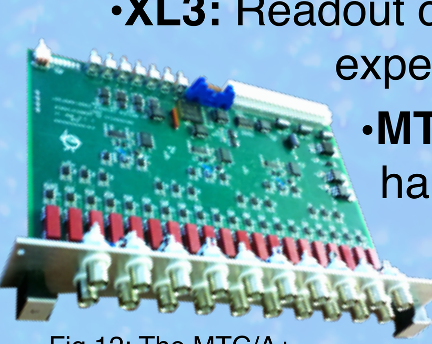
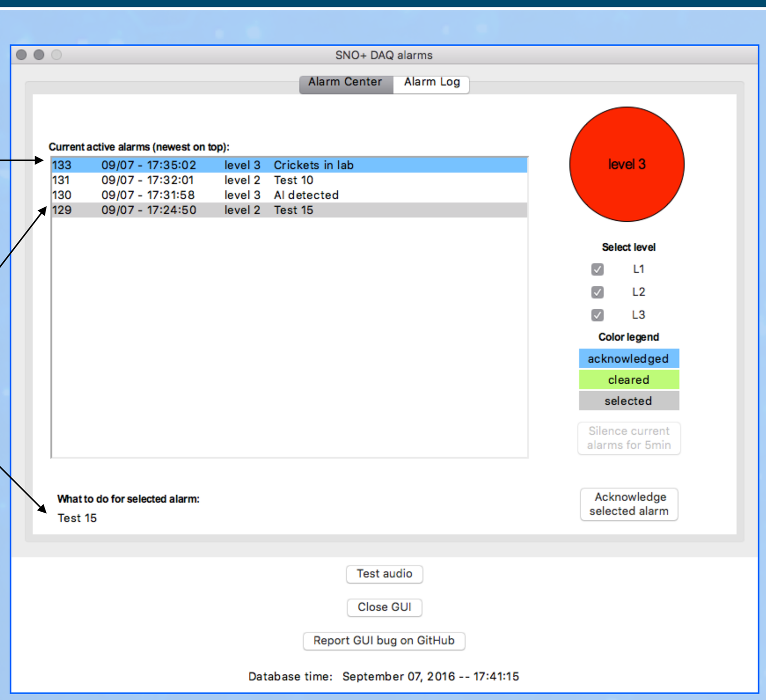


Fig.12: The MTC/A+.

- **MTC/A+:** Trigger cards have ability to handle the larger currents created by the greater number of PMT hits. These also provide baseline stabilization and monitoring of triggers.
- **CAEN digitizer:** Adds trigger waveforms to the event data, used in the tagging of instrumental backgrounds.
- **TUBii**: Utility board providing pulsers and delays for calibration sources, extra trigger ports, a backup clock and other useful functions.

Fig.13: The trigger utility board.

Monitoring and Alarms



A new, robust central alarm system has been designed. The alarm GUI displays the state of the alarm database and allows the operators to filter and acknowledge alarms.

Commissioning

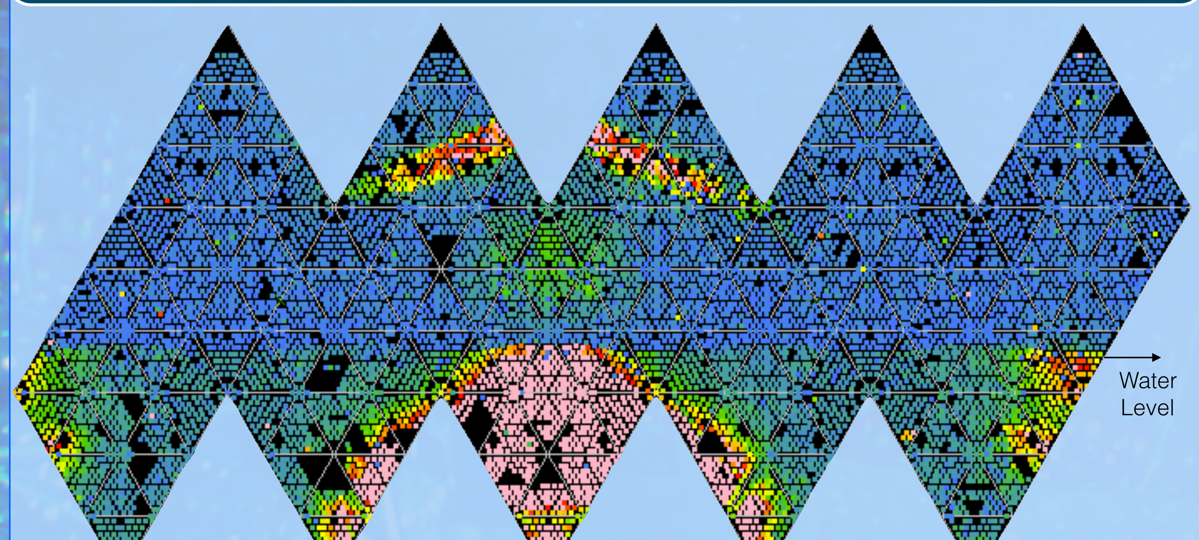


Fig.14: A flat-map view of the SNO+ detector in which each dot represents one PMT. The color-scale indicates light-intensity. This represents a summed data-set with light emitted by one of the calibration fibers that is mounted in between the PMTs.

The detector has been turned on when partially filled with water at several occasions for commissioning the electronics and DAQ. This was also valuable for expert operator training.

Conclusion and Schedule

Significant work has taken place to transform the heavy water detector of SNO into a liquid scintillator detector. The LBNL group has leading roles in calibration, analysis and DAQ efforts. The upcoming initial Water Phase allows commissioning of electronics, DAQ, calibration systems as well as physics searches like invisible nucleon decay.

Schedule

- We are getting ready to start data-taking.
- Currently filling detector with ultra pure water.
- Water-phase physics data in early 2017.
- Scintillator Phase mid 2017.
- Tellurium Phase early 2018.